Iris Recognition

Introduction

Iris recognition is the process of recognizing a person by analyzing the random pattern of the iris (Figure 1). The automated method of iris recognition is relatively young, existing in patent only since 1994.[1]

The iris is a muscle within the eye that regulates the size of the pupil, controlling the amount of light that enters the eye. It is the colored portion of the eye with coloring based on the amount of melatonin pigment within the muscle (Figure 2).

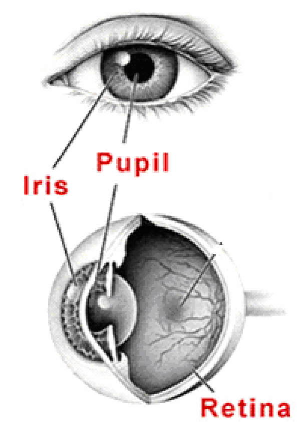

Figure 1: Iris Diagram[2]

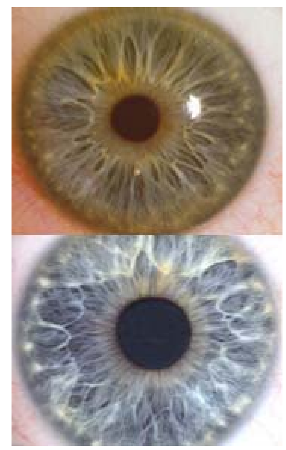

Figure 2: Iris Structure.[3]

Although the coloration and structure of the iris is genetically linked, the details of the patterns are not. The iris develops during prenatal growth through a process of tight forming and folding of the tissue membrane.[4] Prior to birth, degeneration occurs, resulting in the pupil opening and the random, unique patterns of the iris.[5] Although genetically identical, an individual's irides are unique and structurally distinct, which allows for it to be used for recognition purposes.

History

In 1936, ophthalmologist Frank Burch proposed the concept of using iris patterns as a method to recognize an individual.[6] In 1985, Drs. Leonard Flom and Aran Safir, ophthalmologists, proposed the concept that no two irides are alike,[6] and were awarded a patent for the iris identification concept in 1987. Dr.

Flom approached Dr. John Daugman to develop an algorithm to automate identification of the human iris. In 1993, the Defense Nuclear Agency began work to test and deliver a prototype unit, which was successfully completed by 1995 due to the combined efforts of Drs. Flom, Safir, and Daugman. In 1994, Dr. Daugman was awarded a patent for his automated iris recognition algorithms. In 1995, the first commercial products became available.[7] In 2005, the broad patent covering the basic concept of iris recognition expired, providing marketing opportunities for other companies that have developed their own algorithms for iris recognition. The patent on the IrisCodes® implementation of iris recognition developed by Dr. Daugman (explained below) will not expire until 2011.[8]

Approach

Before recognition of the iris takes place, the iris is located using landmark features. These landmark features and the distinct shape of the iris allow for imaging, feature isolation, and extraction. Localization of the iris is an important step in iris recognition because, if done improperly, resultant noise (e.g., eyelashes, reflections, pupils, and eyelids) in the image may lead to poor performance.

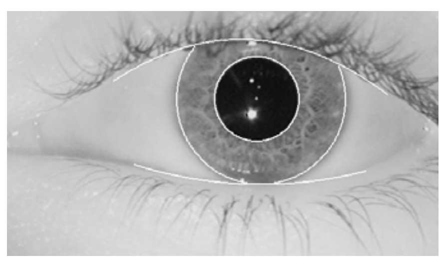

Figure 3: White outlines indicate the localization of the iris and eyelid boundaries.[3]

Iris imaging requires use of a high quality digital camera. Today's commercial iris cameras typically use infrared light to illuminate the iris without causing harm or discomfort to the subject.

Upon imaging an iris, a 2D Gabor wavelet filters and maps the segments of the iris into phasors (vectors). These phasors include information on the orientation and spatial frequency ("what" of

the image) and the position of these areas (“where” of the image).[9] This information is used to map the IrisCodes® (Figures 4 & 5).

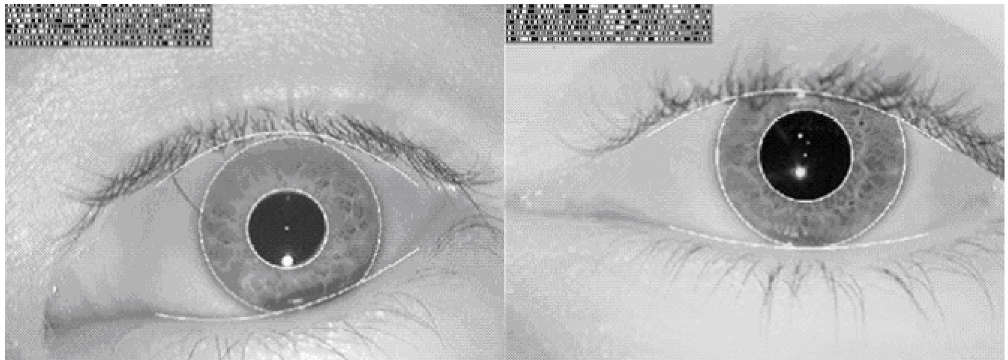

Figure 4: Localized Irides with IrisCodes®. [3]

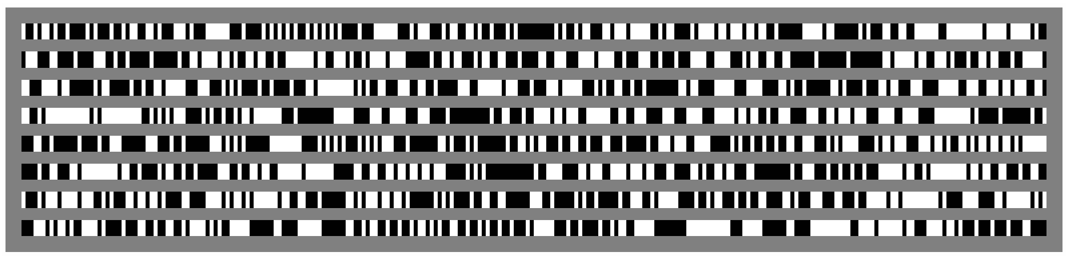

Figure 5: Pictorial Representation of IrisCode®. [3]

Iris patterns are described by an IrisCode® using phase information collected in the phasors. The phase is not affected by contrast, camera gain, or illumination levels. The phase characteristic of an iris can be described using 256 bytes of data using a polar coordinate system. Also included in the description of the iris are control bytes that are used to exclude eyelashes, reflection(s), and other unwanted data.[10]

To perform the recognition, two IrisCodes® are compared. The amount of difference between two IrisCodes® — Hamming Distance (HD) — is used as a test of statistical independence between the two IrisCodes®. If the HD indicates that less than one-third of the bytes in the IrisCodes® are different, the IrisCode® fails the test of statistical significance, indicating that the IrisCodes® are from the same iris. Therefore, the key concept to iris recognition is failure of the test of statistical independence.[10]

Iris vs. Retina Recognition

As discussed above, iris recognition utilizes the iris muscle to perform verification. Retinal recognition uses the unique pattern of blood vessels on an individual's retina at the back of the eye. The figure below illustrates the structure of the eye.

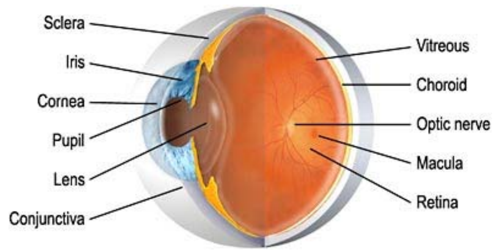

Figure 6: Structure of the Eye.[11]

Both techniques involve capturing a high quality picture of the iris or retina, using a digital camera. In the acquisition of these images, some form of illumination is necessary. Both techniques use NIR (near infrared) light. Although safe in a properly designed system, eye safety is a major concern for all systems that illuminate the eye. Because infrared has insufficient energy to cause photochemical effects, the principal potential damage modality is thermal. When NIR is produced using light emitting diodes, the resulting light is incoherent. Any risk for eye safety is remote with a single LED source using today's LED technology. Multiple LED illuminators can, however, produce eye damage if not carefully designed and used.

United States Government Evaluations

The US Department of Homeland Security (DHS) and the Intelligence Technology Innovation Center (ITIC) co-sponsored a test of iris recognition accuracy, usability, and interoperability referred to as the Independent Testing of Iris Recognition Technology (ITIRT) (http://www.biometricscatalog.org/itirt/ITIRT-FinalReport.pdf), the results of which were released in May 2005. The scenario test evaluated enrollment and matching software, and acquisition devices. The ITIRT's primary objective was to evaluate iris recognition performance in terms of match rates, enrollment and acquisition rates, and level of effort required from the user. The evaluation of match rates determined the

ability of algorithms to correctly match samples in a variety of intra-device and cross-device test cases based on genuine and impostor comparisons. The enrollment and acquisition evaluation determined the ability of the subject acquisition devices to successfully enroll IrisCodes® and acquire iris samples from test subjects. The level of effort evaluation determined the ability of these devices to acquire iris images and IrisCodes® from test subjects with minimal transaction durations and repeated attempts. ITIRT did not evaluate iris recognition systems in terms of availability, liveness detection, or ease of integration with external systems.[12]

The National Institute of Standards and Technology (NIST) is conducting the Iris Challenge Evaluation (ICE) (http://iris.nist.gov/ICE/), a two-phase large-scale independent development and technology evaluation of iris recognition technology to assess the current state of the art and to promote the development and advancement of iris recognition technology. Phase I will present an iris challenge problem while Phase II will measure the performance of the technology using a standard dataset and test methodology.[13]

Standards Overview

Current standards work in the area of iris recognition exists on the national and international level. The "ANSI/INCITS 379-2004 Iris Interchange Format"[15] and "ISO/IEC 19794-6: 2005 Biometric Data Interchange Format – Part 6: Iris image data"[15] standards are the major iris recognition standards and define two data formats for representing an iris image. The first format utilizes a rectilinear format in which the image can be raw or compressed and can vary in size based on field of view and compression or color (gray or color intensity levels).[14] The second format utilizes a polar image specification with specific preprocessing and segmentation steps for the image, which can be raw or compressed; contains only iris information; and is much more compact than the first.[16] These standards also define data structures and headers to support the storage of interoperable information[14] and will provide interoperability among vendors by providing a compact method of human iris representation. The current state of the technology allows for interoperability only through the transmission of the whole iris image, which requires storage of excess data and high bandwidth and introduces additional sources of errors through lengthy data transmissions processes.

Products must adhere to the illumination safety standards ANSI/IESNA RP-27.1-96 and IEC 60825-1 Amend.2, Class 1 LED, the latest worldwide standards in the illumination safety area, to ensure safe use of infrared technology.

Other standards, such as INCITS 398-2005 Common Biometric Exchange Formats Framework (CBEFF), deal specifically with the data elements used to describe the biometric data in a common way. Another standard is the INCITS 358-2002 BioAPI Specification that defines the Application Programming Interface and Service Provider Interface for a standard biometric technology interface. National and international standards organizations are working to continue the progression of the standards in a direction to facilitate growth, advancement, and interoperability.

Summary

Having only become automated and available within the past decade, the iris recognition concept and industry are still relatively new so a need for continued research and testing remains. Through the determination and commitment of industry, government evaluations, and organized standards bodies, growth and progress will continue, raising the bar for iris recognition technology.

Document References

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The National Science and Technology Council (NSTC) was established by Executive Order on November 23, 1993. This Cabinet-level Council is the principal means within the executive branch to coordinate science and technology policy across the diverse entities that make up the Federal research and development enterprise. Chaired by the President, the membership of the NSTC is made up of the Vice President, the Director of the Office of Science and Technology Policy, Cabinet Secretaries and Agency Heads with significant science and technology responsibilities, and other White House officials.

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- Coordinates biometrics-related activities that are of interagency importance;
- Facilitates the inclusions of privacy-protecting principles in biometric system design;
- Ensures a consistent message about biometrics and government initiatives when agencies interact with Congress, the press and the public;
- Strengthen international and public sector partnerships to foster the advancement of biometric technologies.

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